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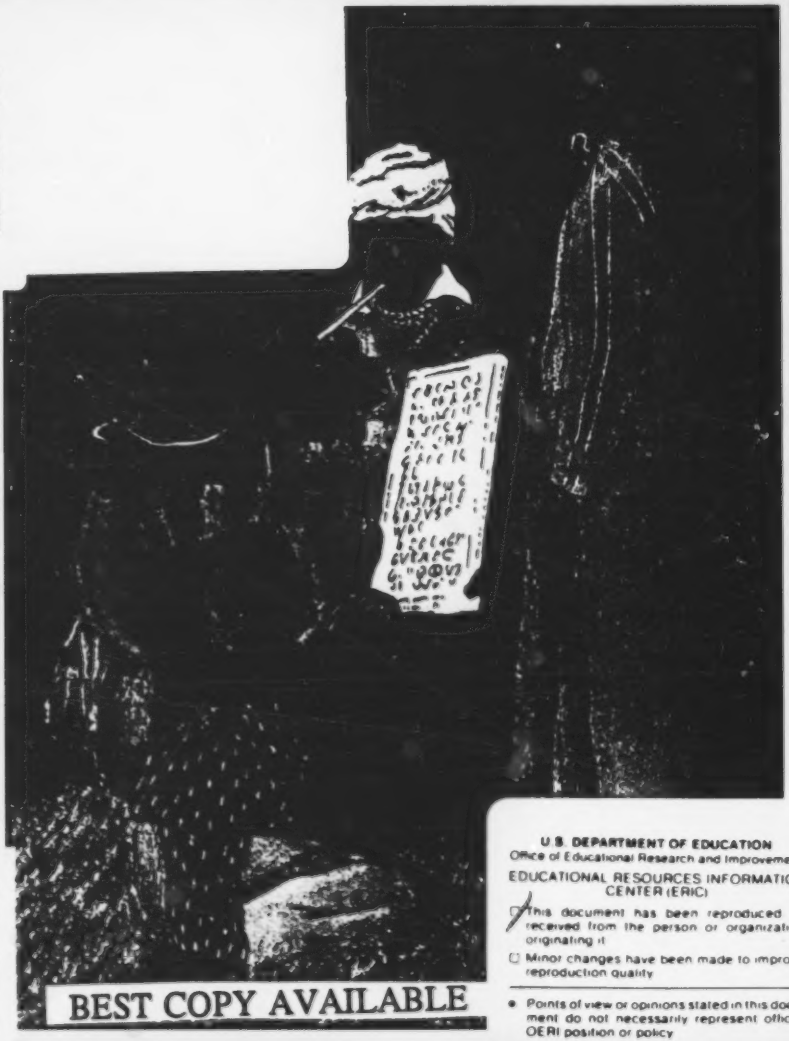
ABSTRACT

A 3-day conference developed guidelines ensuring that cultural needs and issues are addressed in mathematics, science, and technology educational programs for American Indian and Alaska Native precollege students. Major barriers affecting these students in mathematics, science, and technology were summarized for three areas (student programs, curriculum development, and teacher programs), and guidelines were developed to address them. Guidelines for student programs include recognizing students for their participation, providing the opportunity to develop as whole persons, establishing mentoring within local communities, and facilitating parental involvement. For curriculum development, guidelines include aligning curricula with the community's needs and goals, including: cultural needs, holistic and spiritual approaches, local knowledge, language, elders, and mentors; using hands-on, cooperative group activities; and ongoing evaluation. Teacher program guidelines include understanding the students' culture; integrating traditional American Indian science, mathematics, and technological knowledge in classroom teaching; employing hands-on, inquiry-based learning, cooperative learning, and problem-solving activities; and making science, mathematics, and technology relevant by including community members and resources in teaching and learning. Three appendices describe the conference; review the literature on barriers to mathematics, science, and technology education for American Indian and Alaska Native students; and list additional resources. (Contains 20 references.) (TD)

Educating American Indian/Alaska Native Elementary and Secondary Students

Guidelines for Mathematics, Science and Technology Programs

ED 385 404



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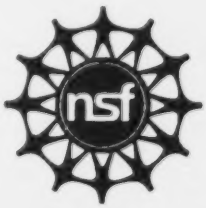

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CONFERENCE SUMMARY

Thirteen guidelines designed for use by educators, administrators, project and grant developers, grant reviewers, funding agencies and others concerned with the mathematics, science and technology education of elementary and secondary American Indian/Alaska Native students were developed from the conference. The Guidelines are:

- Recognize students for their participation and progress in science, mathematics, and technology as well as their general participation in the schooling process.

- Provide students with the opportunity to develop themselves as whole persons: emotionally, spiritually, physically, and mentally. Include a needs analysis of student learning styles and cultures.

The primary goal of this project was to develop a set of recommended guidelines for ensuring that cultural needs and issues are addressed.

- Establish meaningful partnerships and mentoring in all schools within their local or neighboring communities and with national organizations.

- Facilitate and effectively implement parental involvement for students to receive maximum educational benefits.

- Assess the current science, mathematics, and technology curricula in terms of the community's needs and goals.

- Align the science, mathematics and technology curriculum with the assessed cultural needs and concerns of the community.

- Include the following (based on the community's needs assessment) in designing a science, mathematics, and technology curriculum: holistic and spiritual approaches; relevant local American Indian/Alaska Native cultural knowledge, materials, methodology, and language utilization; leadership training; and community elders, role models, and mentors.

- Use the following methods or sources to meet the cultural needs of students and communities: hands-on, inquiry- based learning; problem-solving; cooperative group activities; and community resources; and current technology.

- Evaluate the curriculum in various ongoing ways including: performance-based evaluation; comparison of the curriculum to the community goals; and tracking the implementation, impact, and outcomes of the curriculum.

As content and culture are blended both are strengthened and provide equal status in teaching and learning.

- Understand the culture of American Indian/Alaska Native students you are teaching.

- Emphasize and integrate American Indian traditional science, mathematics, and technological knowledge in classroom teaching.

- Become skilled in a variety of teaching/learning styles appropriate to American Indian/Alaska Native students, such as hands-on, inquiry-based learning; cooperative learning; use of technology in teaching and learning; and problem-solving activities.

- Make science, mathematics, and technology education relevant to American Indian/Alaska Native students by including community members and resources in teaching and learning.

INTRODUCTION

"Indian people want their children to value their culture and traditions, but they also want their children to have basic academic competencies and subject-matter knowledge. Among the critical issues for American Indians is how to reconcile Indian spiritual values and formal education."

The College Board/AISES, 1989

This document was developed from a three-day conference held in May 1994 in Boulder, Colorado, sponsored by the American Indian Science and Engineering Society's Research and Evaluation Department under a grant from the National Science Foundation.

The primary goal of this project was to develop a set of recommended guidelines for ensuring that cultural needs and issues are addressed in mathematics, science, and technology educational programs for American Indian/Alaska Native precollege students. Specifically, conference participants focused their discussions on the following two questions:

1. *What are the major barriers, concerns, and issues that should be addressed in any student, curriculum and teacher preparation project for American Indian/Alaska Native students?*

2. *What strategies or methods should be employed to ensure that the cultural issues identified are addressed in student, curriculum and teacher preparation projects for American Indian/Alaska Native precollege students?*

These guidelines complement other relevant guidelines and documents that shape programs and projects in science, mathematics, and technology education for American Indian/Alaska Native precollege students. The intended purposes of this document are to provide the following:

- Guidance to those who are designing, implementing, and evaluating science, mathematics, and technology programs for American Indian/ Alaska Native precollege students

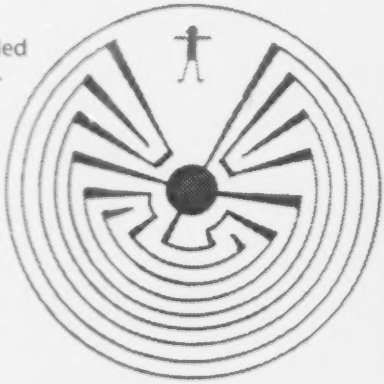
- Guidance to those who are working in science, mathematics, and technology areas for American Indian/Alaska Native students

- Guidance to funding agencies and project and proposal reviewers covering mathematics, science, and technology education for American Indian/Alaska Native precollege students

Teachers must evaluate themselves and their understanding of their own culture as an initial first step in understanding another culture, and in incorporating that culture in their teaching and learning.

Although specific content in mathematics, science, and technology was not discussed directly, its importance in teaching and learning was recognized throughout the conference proceedings. *As content and culture are blended, both are strengthened and provide equal status in teaching and learning.*

The structure of this conference modeled strategies and procedures considered effective in working with American Indian/ Alaska Native students and their teachers, including cooperative work groups, concept webbing, problem- solving activities, and a cultural awareness of American Indian/Alaska Native values. For a discussion of the conference design, procedures, and agenda, see Appendix.



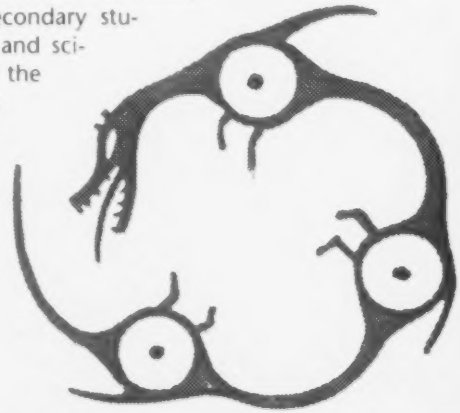
PRECONFERENCE PREPARATION

Preconference preparation included readings to help participants focus on the conference goals. The first, Our Voices, Our Vision: American Indians Speak Out for Educational Excellence (College Board/American Indian Science and Engineering Society, 1989), focused on the National Dialogue Project on American Indian Education. Participants voiced their wants and needs through a series of regional dialogues.

> ***Spirituality is an important aspect of American Indian/Alaska Native learning and lifestyle. By including this aspect in curriculum development, it recognizes the value of American Indian/Alaska Native spirituality.***

The second reading, "Toward a Redefinition of American Indian/Alaska Native Education" (Hampton, 1992), provided a summary of views toward education for American Indian/Alaska Natives. It discusses the current state of Indian education and addresses five different ways Indian education has been viewed, reflecting both Indian and non-Indian perspectives.

The third reading, which came from the grant proposal for the conference, focused on the barriers that American Indian/Alaska Native elementary and secondary students encounter in mathematics and science education. This review of the literature highlighted issues such as Western versus Native views, cultural relevance, learning styles, institutional barriers, lack of role models, psychological dynamics, language, and cultural insensitivities, see Appendix B.



CONFERENCE OUTCOMES

Each of the conference's three topical areas (student programs, curriculum development, teacher programs) generated two major outcomes:

1. A summary of major issues or barriers affecting American Indian/Alaska Natives in mathematics, science, and technology

2. Guidelines to meet these issues and to provide effective education to elementary and secondary American Indian/Alaska Native students and to their educators

Some of the issues within the topical areas overlap, highlighting the important interrelationship among student, curriculum, and teacher programs. In developing or implementing any one of these program areas, one should consider guidelines from all three because much interconnectedness occurs. Also, these guidelines are not necessarily specific only to science, mathematics, and technology; rather, they encompass many educational aspects within precollege teaching and learning for American Indian/Alaska Native students.

Student Programs

The barriers, issues, and concerns affecting Native American/Alaska Native precollege students can be summarized as follows:

- American Indian students suffer from a disproportionately high dropout rate when compared to the general population, resulting in an insufficient number of American Indian/Alaska Native role models in mathematics and science teaching positions, decision-makers within the educational system.
- Parental involvement is not adequately pursued or developed.
- Social issues relevant to the student's lives are not taken into consideration in their schooling.
- A lack of effective counseling services exist to encourage enrollment in the science, mathematics and technology fields.
- The language used within science and mathematics is often foreign for many American Indian/Alaska Native precollege students.
- Many students must cope with discrimination in school, highlighting the lack of acknowledgment for their culture/communities.

- As girls are often overlooked in science and mathematics, they are not adequately encouraged to pursue careers in these areas.
- Students are exposed infrequently to relevant American Indian/Alaska Native issues in the science, mathematics, and technology experiences they have in school.
- Science, mathematics, and technology education frequently is culturally irrelevant to students and their communities. This leaves gaps in the development of a meaningful and relevant education.
- The community and the school often are not connected in their views of students' educational goals, causing conflict among all groups involved with the educational process.

Incorporating a holistic teaching approach in the classroom promotes mental, emotional, physical and spiritual well-being in an individual student. This is the foundation on which American Indian/Alaska Native people have based their societies for centuries.

Issues such as inadequate secondary school counseling, insufficient access to American Indian/Alaska Native role models, lack of cultural relevance, and the lack of school-community partnerships all contribute to inadequate and ineffective student programs in elementary and secondary education. These issues served as a reference in the generation of important factors to consider to ensure culturally relevant education.

Figure 1 illustrates the conference participants' concept web identifying the critical factors to consider when designing and implementing educational mathematics, science, and technology programs for American Indian/Alaska Native precollege students.

The participants also generated four guidelines reflecting these critical factors for effective precollege student programs:

Guideline 1.1 - *Recognize students for their participation and progress in science, mathematics, and technology, as well as for their general participation in the schooling process.*

Figure 1: Critical factors in student programs

Students need to be recognized in their schools and communities as important contributing members. One way to achieve this is through their school accomplishments. Recognition should be culturally compatible within the community; valuing and honoring of the common person is very important. For example, student work such as science and mathematics projects should be displayed throughout the school and in suitable community buildings.

Special program administrators should use the local and/or regional media to inform the community of events that feature mathematics, science, or technology, such as science fairs or invention conventions. When students attend a summer program, a press release should be sent to community media services.

Guideline 1.2 - *Provide students with the opportunity to develop themselves as whole persons: emotionally, spiritually, physically, and mentally. Include a needs analysis of student learning styles and cultures.*

Educators and administrators should offer students a variety of avenues for setting and achieving their educational goals. A needs analysis should reflect the emotional, spiritual, physical, and mental needs of students and their community. To best develop the whole person and meet individual learning styles, schools should establish programs, classes, and projects that accurately reflect the needs analysis. Extensive counseling services and tutorial programs must be given top priority and career counseling must be in place for each student. Extracurricular activities should be accessible to all students, and transportation issues should not obstruct student participation. Field trips to museums, science centers, urban areas, universities, or tribal colleges need to be incorporated into the curriculum of the total school program.

Guideline 1.3 - *Establish meaningful partnerships and mentoring in all schools within local or neighboring communities and with national organizations.*

Mentoring within the school that involves students, teachers, staff, and administrators must be established. Several models for such programs are in use across the country. (See the appendix for names of places and organizations that provide services in mathematics, science, and technology.) In addition to in-house programs, partnerships with community organizations and businesses should be set up. Schools should be able to combine, modify and establish programs that accurately reflect the needs of the community and local culture. Contacts with national corporations and organizations for establishing summer corporate mentorship programs can be made and developed. Two-way communication is critical and must be built into any partnership.

Guideline 1.4 - *Facilitate and effectively implement parental involvement for students to receive maximum educational benefits.*

Parents are the primary educators of their children and must have the opportunity for meaningful input into children's education. The nation's schooling system has disenfranchised American Indian/Alaska Native parents into thinking that they have no such rights. Schools must include parents as vital partners in the educational process. Traditional parent-teacher organizations need to be modified and enhanced to encompass all family situations. Parent-teacher conferences must be modified to meet the

schedules of both parents and students. Further, it is important to remember that the best location for parent-teacher interactions may not always be at the school, but instead at some other community location.

Curriculum Development

The barriers, issues, and concerns affecting curricula for precollege American Indian/Alaska Native students can be summarized as follows:

- Community needs and concerns are neither adequately identified nor integrated into the educational process, resulting in unnecessary and unresolved conflict between the school and community.
- Current curricula are not inclusive of American Indian/Alaska Native views. Research has shown that this constant neglect negatively affects minority students and how they view themselves as learners in the dominant society.
- Elders and other American Indian/Alaska Native experts are not consulted to ensure that their knowledge is incorporated into the development process of science, mathematics, and technology curricula.
- Current curricula are not holistic in scope. The American Indian/Alaska Native lifestyle of balance and holism is not supported in the hierarchical style of modern science and mathematics.
- Curriculum evaluation practices do not reflect cultural relevancy. Additional or adapted evaluation instruments are necessary to evaluate student progress, as current test-taking practices do not accurately reflect American Indian/Alaska Native students' understanding of science, mathematics, and technology.
- Spirituality comprises an important aspect of American Indian/Alaska Native learning and lifestyle, and current curricula do not foster the spiritual relationship among people and their environment. Ignoring this aspect devalues the important relationship that American Indians/Alaska Natives have with the Earth.
- Financial support for programs is insufficient for sustainability. When such resources become available to help facilitate growth, they often disappear before a program is firmly established and integrated into the school and community.
- Good academic programs do not always get support from the school and community. Communication among school and community groups is not adequately in place, causing confusion, apathy, and mistrust.

Issues such as lack of cultural relevance, little or no reference to American Indian/Alaska Native contributions to society and the sciences, lack of reference to community and spirituality, and the isolated study of topics all contribute to inadequate and ineffective curricula for elementary and secondary American Indian/Alaska Native students. These issues served as a reference in the generation of the important factors to consider to ensure culturally relevant education.

Figure 2 illustrates the conference participants' concept web identifying the critical factors to consider when designing and implementing mathematics, science, and technology curricula for American Indian/Alaska Native precollege students and their educators.

The participants also generated five guidelines reflecting these critical factors for effective curriculum development projects:

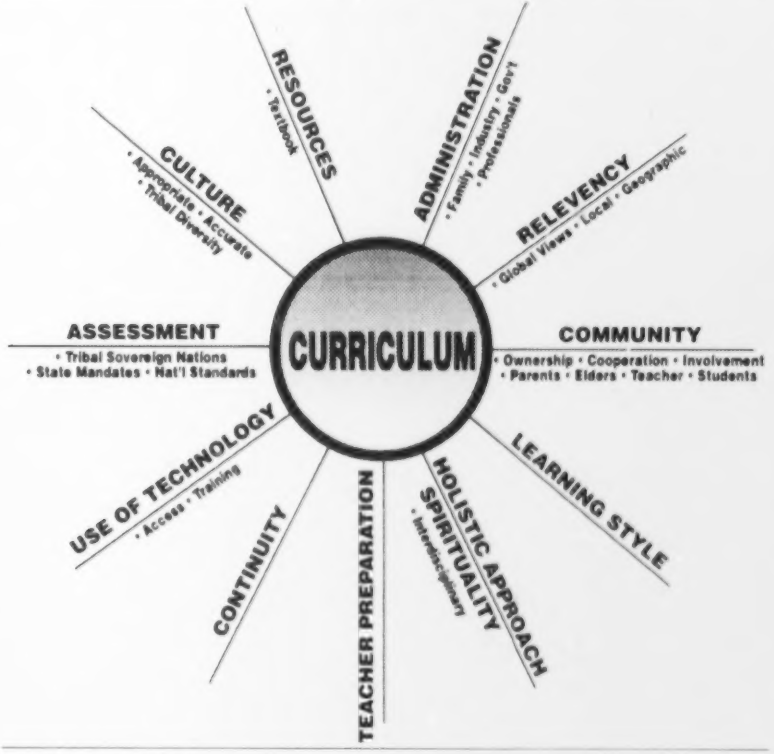


Figure 2: Critical factors in curriculum development

Guideline 2.1 - *Assess the current science, mathematics, and technology curricula in terms of the community's needs and goals.*

These community needs should be identified from the stakeholders' input. Stakeholders in the American Indian/Alaska Native community need to be identified and recognized, keeping in mind that the curriculum impacts beyond the classroom; some of them are the parents, students, teachers/facilitators, elders, school board members, tribal and other local government representatives, and additional interested community members. Existing as well as new mechanisms and networks should be used to engage all interested parties in the curriculum. An example of this would be to hold a community meeting at the village or chapter house to discuss the roles, rules, and responsibilities for the science, mathematics, and technology program that will operate within the community. Additionally, social interactions are important to engage stakeholders' participation. To be most effective, some type of professional compensation for these resources should also be considered. Planners should base mathematics, science, and technology curricula on local community needs.

Guideline 2.2 - *Align the science, mathematics, and technology curricula with the assessed cultural needs and concerns of the community.*

Once the needs assessment has been completed (Guideline 2.1) and vital information has been gathered, the curricula in science, mathematics, and technology should be aligned accordingly. Credibility from and accountability to the local community is vital. The existing tribal, national, and state science and mathematics goals also should be recognized, including identifying the strengths and deficiencies in the current curriculum. The missing and/or needed curriculum elements then must be addressed. The existing administrative support of the curriculum should be identified and expanded, as this is necessary for curricula continuity, resources, and materials. If the curriculum is to function as a shared creation between the developers and the community, it is essential to keep everyone's needs and goals in mind.

Guideline 2.3 - *Include the following (based on the community's needs assessment) in designing a science, mathematics, and technology curriculum: holistic and spiritual approaches; relevant local American Indian/Alaska Native cultural knowledge, materials, methodology, and language utilization; leadership training; and community elders, role models, and mentors.*

Spirituality is an important aspect of American Indian/Alaska Native learning and lifestyle. By including it in curriculum development, planners acknowledge its value of American Indian/Alaska Native students. Textbooks in science and mathematics do not emphasize this approach and should be augmented with Native American/Alaska Native stories or examples to ensure cultural relevance.

Holistic approaches include learning that organizes the curriculum around the students life, culture, and environment. Broad-theme subjects should be used, such as pollution or weather. American Indian/Alaska Native stories and legends, life experiences, and observations should be included in holistic curricula. Mathematics and science programs should draw existing knowledge and experiences within the community and culture to enhance the students' curricular experiences.

Research regarding the attributes of effective instruction with American Indian/Alaska Native students indicates that hands-on, inquiry based, cooperative learning and holistic learning practices are appropriate approaches to effective classroom learning.

All communities have different needs, and thus recognizing the diversity among American Indian/Alaska Native communities is necessary. Planners should use the community needs assessment as a guide for relevant local American Indian/Alaska Native cultural subjects, materials, methodology, and language utilization. Community guidance can help discard American Indian/Alaska Native stereotypes and misconceptions, as can inter-cultural sharing and exchanges with other communities. Accurate and factual information only should be used. By making students aware of their communities' needs and global perspectives, these are passed then onto the next generation.

Although some of these above approaches differ significantly from current practices, they reflect the current reform movement. Because some of these approaches or areas of emphasis may be new in curriculum development, they also may be new to the students' experience. Consequently, leadership training is necessary in the implementation of curricula that adhere to these guidelines. Through this type of relevant curriculum American Indian/Alaska Native students may become future leaders in their

communities, especially as they apply their science, mathematical, and technological abilities.

In identifying role models and mentors, all community members who wish to share life experiences should be considered. Parents and family members are a part of students' education both in and out of the school setting. American Indian/Alaska Native individuals recognize the education of a whole person as one who is academically "smart" while also mentally, physically, and spiritually balanced, and in harmony with self and the environment.

Guideline 2.4 - *Use the following methods and sources to meet the cultural needs of students and communities: hands-on, inquiry-based learning; problem solving; cooperative group activities; community resources; and current technology.*

Applicable and current community needs can be used as hands-on, problem-solving exercises. Students should be made aware of these issues so they can work toward practical solutions to their communities' needs. A culturally appropriate example would be students researching and gathering water samples from a nearby river because their community needs to monitor and be aware of its water quality. By using the community itself as a teaching tool, practical, useful, and positive methods enhance the student's learning.

Students need to be recognized in their schools and communities as important contributing members.

A holistic approach as mentioned previously is fundamental to effective curriculum for American Indian/Alaska Native students. Linear thought processing is only one way to learn or teach. Learning and teaching also can be accomplished through observation, experience, and exploration. For example, teachers can present complex issues and problems that do not have predetermined answers or solutions.

Co-learning methods should also be used when possible. This allows for coaching and guiding, and deemphasizes the teacher in a highly directive role. Groups of students should have a chance to participate through cooperative, nurturing, and communicable activities. Variety in the activi-

ties also accommodates different learning styles and develops respect for different styles. Planners also must keep in mind the students' maturity level. Developing self-awareness and personal confidence facilitates effective learning and should become central to the curricular experiences.

Technology should be researched and evaluated before its implementation. Cultural integrity must be maintained where current and emerging technology are used in the curriculum and community. Technology can be a very valuable tool in improving curricular experiences; however, if not used within the proper cultural context it also can deter learning. Planners should conduct a community technological needs assessment prior to implementing technology in the community and school.

Guideline 2.5 - *Evaluate the curriculum in various ongoing ways including performance-based evaluation; comparison of the curriculum to the community goals; and tracking the implementation, impact, and outcomes of the curriculum.*

A process of evaluation needs to be established as the curriculum is being developed and field tested. Procedures should include an: Implementation Evaluation (assessment of the project timelines), a Progress Evaluation (assessment of project objectives), and a Summative Evaluation (assessment of the impact of the project). Both qualitative and quantitative information should be gathered on all aspects of the project.

The current level and status of the curriculum's accreditation needs must be recognized. However, in addition to the community and school's accreditation criteria and national or state accreditation demands, tribal and/or cultural standards must be met.

Broad-based views in evaluating curricula look beyond grades and memorization to a more complete understanding of the subjects presented. Another aspect of appropriate evaluation is to ensure that students share or apply the information learned with their parents, community, or peers. Evaluation of curriculum should attempt to answer questions such as, did the curriculum meet the community's goals? did the curriculum go beyond the classroom? was the curriculum connected to the community?

If the evaluation evolves naturally from the community needs assessment in the curriculum development, American Indian/Alaska Native students have the best chance of learning mathematics, science, and technology content and skills in a culturally relevant, inquiry-based, and cooperative way.

Teacher Preparation and Enhancement

The barriers, issues and concerns affecting teacher preparation and enhancement can be summarized as follows:

- Training is not always available or provided to help teachers make their science, mathematics, and technology instruction culturally compatible with students' backgrounds and community needs.
- There is insufficient support for teacher enhancement programs that can help close the gap between teachers, students, and the Native American/Alaska Native community.
- Teacher preparation/enhancement programs do not use curricula relevant to students' background, culture, and experiences to improve their science, mathematics, and technology skills and knowledge.
- Teachers do not possess the skills and/or support necessary to create balance between native and modern scientific thought processes.
- Many teachers lack the knowledge or training necessary to prepare students for science, mathematics, and technology outside of the classroom.
- Teachers do not use a variety of inquiry-based, problem-solving teaching techniques in order to reach all students.
- Many teachers lack sufficient training to help students acquire information through methods most compatible with their preferred learning styles.
- Teachers are not provided sufficient opportunities to communicate their goals and strategies for facilitating science, mathematics, and technology education of American Indian/Alaska Native precollege students with their colleagues, parents, and the students themselves.
- Opportunities and financing for field trips supportive of the science and mathematics curricula are inadequate, and thus do not provide the experiences necessary to promote these areas, particularly for rural and reservation schools.
- Teachers are often uncomfortable teaching science, mathematics, and technology content because of their limited formal education and hands-on experiences in these areas.
- Teachers are not provided sufficient opportunities and follow-up in science, mathematics, and technology to remain current in these fields.

Figure 3: Critical factors in teacher programs

Issues such as lack of adequate preservice and inservice education, insufficient opportunities to remain current in mathematics, science, and technology, lack of school-community communication, and little use of hands-on, inquiry-based, cooperative learning all contribute to inadequate teaching skills and knowledge, and subsequent ineffective implementation of instruction in elementary and secondary classrooms for American Indian/Alaska Native students. These issues served as a reference in the generation of important factors to consider to ensure culturally relevant education.

Figure 3 illustrates the conference participants' concept web identifying the critical factors to consider when designing and implementing mathematics, science, and technology programs for American Indian/Alaska Native precollege students and their educators.

The participants also generated four guidelines reflecting these critical factors for effective teacher preparation and enhancement programs:

Guideline 3.1 - *Understand the culture of the American Indian/ Alaska Native students being educated.*

American Indian/Alaska Natives are divided into many cultures, clans, and societies. They practice many customs and lifestyles, maintain an enormous variety of values and beliefs, and speak numerous languages. Programs cannot categorize the diversity of cultures into a single entity or overlook the social and cultural diversity of American Indian/Alaska Natives for the sake of convenience or simplification. American Indian/Alaska Natives make up 1% of the United States population and account for 50% of the country's diversity (Hodgkinson, 1990). Respect for and sensitivity to the local American Indian/Alaska Native population and community can be achieved through the development and implementation of cultural models and courses that are based on collaborative and meaningful input

Once the needs-assessment has been completed and vital information has been gathered, the curricula in science, mathematics and technology should be aligned to meet the community's needs.

of the local population. Ongoing dialogue with tribal members, orientation sessions that include discussion with tribal historians and elders, invitations to attend tribal social gatherings, and commitment to include community involvement are essential to an understanding from the local community. It is also important to bear in mind that for individuals to understand another culture, they must first understand their own and its relationship to the other. Teachers must evaluate themselves and their understanding of their own culture as a first step toward understanding another culture, and in incorporating that culture into their teaching and learning.

Parental involvement in classrooms, on advisory boards and school boards, and as program role models, mentors, and consultants is essential. Program designs must be based on the needs of the local population, as schools make up only one part of the total educational process for American Indian/Alaska Native precollege students.

Guideline 3.2 - *Emphasize and integrate American Indian traditional science, mathematics, and technological knowledge in classroom teaching.*

Once an understanding of culture occurs, traditional knowledge of science, mathematics, and technology can be further developed through community-based interactions among teachers, students, administrators, parents, and community members. Through this interaction American Indian/Alaska Native tribal language and culture can be incorporated into the curricula with proper support from appropriate adult Native Americans/Alaska Natives.

As teachers strive to ensure cultural relevancy in their teaching, American Indian/Alaska Native lifestyles and their relationship with nature and problem-solving techniques should serve as the foundations for effective study of science, mathematics, and technology. The historical and contemporary perspectives of science, mathematics, and technology as they relate to communities comprise an integral part of the education process. Through this interrelationship, education in these content areas becomes relevant to American Indian/Alaska Native precollege students.

Guideline 3.3 - *Become skilled in a variety of teaching/learning styles appropriate to American Indian/Alaska Native students, such as hands-on, inquiry- based learning; cooperative learning; use of technology in teaching and learning; and problem-solving activities.*

Research regarding the attributes of effective instruction with American Indian/Alaska Native students indicates that hands-on, inquiry-based, cooperative learning and holistic learning practices are appropriate approaches to effective classroom learning (Gilliland, 1988). Incorporating a holistic teaching approach in the classroom promotes mental, emotional, physical, and spiritual well-being in an individual student. This is the foundation on which American Indian/Alaska Native people have based their societies for centuries. When used appropriately, these and similar methods help prepare students for both individual and cooperative group tasks. Further, the *National Science Education Standards* and the *National Council of Teachers of Mathematics Standards* emphasize these and similar approaches. However, such techniques must be coordinated with the local cultural and community needs to be most effective.

To best use these approaches and implement the science and mathematics standards, teachers must be encouraged to identify and use resources outside the school environment (e.g., Internet), nurture a collaborative approach to work with the community (e.g., school-community alliances), and also plan and implement professional growth and development strategies for themselves and the community population.

Guideline 3.4 - *Make science, mathematics, and technology education relevant to American Indian/Alaska Native students by including community members and resources in teaching and learning.*

A primary barrier to American Indian/Alaska Native participation in science and mathematics is the lack of relevance to Indian lives and to their survival as a culture/community. Defining educational outcomes begins with parents, students, school personnel, and other stakeholders communicating their needs and ideas with one another. Students must be prepared for success in two worlds: their specific society and the dominant society. As discussed previously, science and mathematics content must be consistent with the national standards. However, applications of science, mathematics, and technology must incorporate both national standards curricula as well as local community knowledge and issues. Teachers must engage in continuous assessment methods that prepare students for standardized evaluations as well as classroom evaluations that are appropriate to their community's culture. To ensure appropriateness within one's culture and community, teachers should:

In actual practice in developing or implementing any one of these three program areas, one should consider guidelines from all three areas since there is much interconnectedness.

- Integrate the backgrounds and experiences of students into lessons
- Utilize existing American Indian/Alaska Native curricula to enhance learning
- Use portfolio assessment to accurately reflect a student's science, mathematics, and technology understandings
- Increase science, mathematics, and technology relevancy to American Indians/Alaska Natives through experiences that foster a connection between classroom learning and actual application of that learning in the community

Community resources (including people) must be viewed as one of the best assets accessible to teachers of American Indian/Alaska Native students. It is through these local resources that community-school alliances are formed, and the most relevant science, mathematics, and technology education and use will occur.

CONCLUSION

The foregoing guidelines and strategies address the various needs, issues, and barriers facing American Indian/Alaska Native precollege students in mathematics, science, and technology education. They are designed for educators and communities committed to providing exemplary and relevant student, curriculum, and teacher programs. These guidelines are adaptable to the needs of individual communities and schools and should be used with this in mind.

The strategies identified represent only a sampling of those in practice. They do, however, represent a variety of programs known to be successful with American Indian/Alaska Native precollege students.

These guidelines may also serve as a means to assess individual teaching practices and pedagogy. The "Suggested Resources" presented in Appendix C provide information on both practice and theory and will increase the knowledge base of educators concerned with science, mathematics and technology education for American Indian/Alaska Native precollege students.

Communities (students, parents, schools, businesses, etc.) may use these guidelines to serve as one means to view their own science, mathematics, and technology programs. The strategies may enhance existing programs or serve as a foundation to explore and build new ones, along with community-school partnerships. On a larger scale, funding agencies may use these guidelines to aid in their review of proposals in science, mathematics, and technology, that purport to serve American Indian/Alaska Native precollege students.

Ideally, this document, along with input from stakeholders at every level, will prove useful in the ongoing development and restructuring of relevant and exemplary mathematics, science, and technology programs for American Indian/Alaska Native precollege students, their teachers, and associated curriculum development. Further, it is the developers' hope that these guidelines will be used to ensure equity and excellence in science, mathematics, and technology programs for American Indian/Alaska Native elementary and secondary students and their educators.

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APPENDIX A:

CONFERENCE DESIGN, AGENDA, AND PARTICIPANT AFFILIATIONS

This conference addressed three interrelated areas: teacher preparation, student programs, and curricula as they relate to community/cultural needs and issues in science, mathematics, and technology education for precollege American Indian/Alaska Native students.

Input from American Indian/Alaska Native people is rarely sought when programs and projects are put into place. Often the needs of the American Indian/Alaska Native populations to be served are not adequately assessed, resulting in ineffective programs and frustration among stakeholders. This conference served as a channel to address the needs facing American Indian/Alaska Native precollege students in science, mathematics, and technology education, as expressed by American Indian/Alaska Native educators and community members from across the country as well as selected others involved in Indian education.

Conference Design

Conference participants included: a) principal investigators and/or their designees on existing National Science Foundation grants that were geared toward American Indian/Alaska Native precollege student programs, teacher programs, or curriculum development; b) other invited participants; c) a National Science Foundation representative; and d) American Indian Science and Engineering Society staff.

Using community resources and people must be viewed as one of the best assets accessible to teachers of American Indian/Alaska Native students.

Conference participants elected to separate into three groups according to their expertise/project representation: teacher programs, student programs, or curriculum development. This breakdown was determined necessary to ensure that cultural needs related to each area were discussed even though overlap exists. The groups were assigned a co-facilitator; however, participants were also assigned to smaller discussion groups as well as mixed larger groups throughout the conference work sessions. Whole-group

discussions occurred periodically throughout the day, and this is when ideas were shared and clarification was explored.

As a result of this conference structure, guidelines were developed through collaborative discussions and group work sessions. Initial discussions centered on individual concerns and experiences with Native American science, mathematics, and technology education. Issues were documented using a concept-webbing procedure that involved identifying major areas related to each of the three topics: student programs, curriculum projects and teacher programs. The concept webs established the foundation for linking similar concerns and issues within topic groups. Periodic discussions with all conference participants ensured consensus on major issues and concerns as well as continued focus on the two conference goals.

Conference Agenda

Conference on the Educational Needs of American Indian/Alaska Native Students in Science, Mathematics and Technology

May 19-22, 1994
College Inn
Boulder, Colorado

Thursday, May 19

2:00	Check In @ College Inn
2:30	Poster Session set up
3:00	Introductions and Blessing
3:30-4:00	Keynote Speaker, Dave Warren (Santa Clara-Tewa) *Issues, Problems, Needs in Mathematics, Science and Technology Education for American Indian Elementary and Secondary Students*
4:00	Welcoming Remarks, Don Jones *Participant Introductions* *Formation of three main groups*
5:30-6:30	Dinner
7:15-8:30	Poster Session and Dessert

Friday, May 20

7:00	Breakfast @ College Inn
8:00	Participants begin to share thoughts identified on their concept web regarding the community/cultural needs and issues in the area of curricula, teacher preparation programs and student programs.
10:30	Small groups reassemble into their main groups and list the needs and issues on large paper to be displayed and discussed with all conference participants.
12:00	Lunch @ AISES headquarters office.
1:30	Whole group sharing Discussion is lead by co-facilitators
5:30	BBQ @ NCAR

Saturday, May 21

7:00	Breakfast @ College Inn
9:00	Three main groups respond to the following question: *What strategies or methods should be employed to ensure that the needs/issues identified on Friday are addressed in teacher, student, and curriculum development projects for American Indian/Alaska Native elementary and secondary students?*
12:00	Lunch @ College Inn
1:00	Continue working in three main groups and discuss strategies.
1:30	Report to whole group. Discuss/combine/clarify strategies.
5:30	Dinner @ College Inn

Sunday, May 22

7:00	Breakfast
8:30	Three main groups describe how strategies can be used to address the needs and issues that have been identified.
10:30	Three main groups discuss possible formats for the final document.
11:00	Whole group sharing
11:30	Closing Ceremony
12:00	Lunch @ College Inn

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APPENDIX B:

REVIEW OF THE LITERATURE ON BARRIERS TO MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION FOR AMERICAN INDIAN/ALASKA NATIVE STUDENTS

Recent reports document that high dropout rates and low academic achievement by American Indian students stem in part from a pervasive disregard for cultural relevancy in the education of American Indian students. In particular, positive early and middle school experiences in science and mathematics are essential to preparing young Indian people for science and engineering careers (Task Force, 1989) yet a review of the literature reveals barriers to such early positive experiences.

Western versus Native View

In contrast to the predominately mechanistic approach of Western science, the Indian view is "holistic in that it tries to present a comprehensive picture in which the parts and their value are less significant than the larger picture and its meaning." American Indian cultures do not accept the separation of science from other aspects of life, yet Indian students are presented with a curriculum in which "knowledge of the world is divided up into separate categories that seem to be completely isolated from each other" (Deloria, 1991 p. 64).

Expressions of a science thought process abound throughout traditional American Indian agriculture, astronomy, ecology, and medical practices. In addition, processes of science that include rational observation of natural events, classification, and problem solving are woven into all aspects of American Indian culture (Cajete, 1986). Despite this intricate knowledge of the natural world, American Indian culture and traditions are often not included in curricula (Deloria, 1991). While mathematics was used in sophisticated ways by many ancient tribal cultures, only Western mathematics history is treated in the classroom (Davison, 1992).

Relevance

Although most scientific knowledge today is passed on via textbooks and rote memorization, traditionally "Indian science was practical, involved a working knowledge of the environment, and was passed on to new generations via stories, games, and the experiences of daily life" (Taylor, 1988). An American Association for the Advancement of Sciences (1977)

report stated that the primary barrier to American Indian participation in science was its lack of relevance to Indian lives and their survival as a culture. Yet even today it is still the rare case where one sees the integration of science and local culture in curricula. Even with this information there has been little movement to change over the last 20 years.

Technology should be researched and evaluated before its implementation. Cultural integrity must be maintained where current and emerging technology are used in the curriculum and community.

In regards to mathematics, textbooks typically are written for white, middle-class American students and present mathematics as an essentially abstract subject (Davison, 1992); teachers also typically present it as such. Mathematics is often not presented in a culturally relevant manner, using situations the students find interesting and familiar (Saxe, 1982). Students see little or no use for the textbook-dominated mathematics they learn in school (Schindler & Davison, 1985), viewing the subject as devoid of meaning, just jargon and symbol manipulation. The result is mathematics underachievement, anxiety, and aversion (Maier, 1985).

Learning Style

The typical approach to classroom teaching has been based largely on a model of education that is teacher directed, employs indirect experience, verbal expression, and a linear approach to learning and thinking, and emphasizes the individual and competition (Pepper in Nelson, 1985). Research regarding the attributes of effective instruction with American Indian students indicates that hands-on, inquiry-based, and cooperative learning are most appropriate (Brendtro & Brokenleg, 1993; Sawyer, 1991). There is dissonance between the "watch me and do as I do" procedures used in most schools and the traditional Indian educational process of "watch me and try it when you feel comfortable with it" (Rhodes, 1990).

Evidence from research and observation indicates that American Indian/Alaska Native students usually do not respond to a verbal, abstract style of mathematics learning and prefer instead familiar tactile and visual stimuli (Davison, 1992). A verbal/abstract mode is often used when a visual/spatial/perceptual mode would be more appropriate. The elementary mathemat-

ics curriculum normally deemphasizes geometry in favor of emphasis on numbers and related operations. Success in geometry is related to a kinesthetic processing of the environment, which is more attuned to the American Indian learning style (Davison, 1992).

Institutional Barriers

In reservation schools, turnover is high (Task Force, 1989). Teachers often lack adequate preparation, support, and delivery mechanisms (MSEB, 1990) and must use outdated materials and poor equipment. Many schools rely on tracking, a system that sorts students into achievers and underachievers and erodes desire to excel in mathematics as well as science (MSEB, 1990).

Lack of Role Models

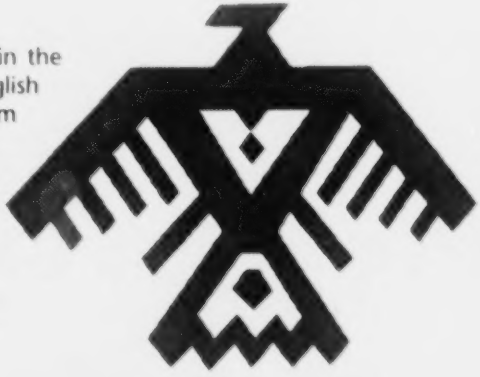
There are few positive American Indian role models in schools. Only six states have a minority student enrollment greater than 15% in their teacher education schools, colleges, and education departments. Out of every 400 students enrolled in teacher education programs nationally, only two are American Indian (MSEB, 1990), and only a small percentage of these students goes on to teach mathematics and/or science.

Psychological Dynamics

The expectations from parents, teachers, and students themselves are low regarding mathematics and science. Lack of self-esteem and lack of self-confidence erode student interest and inadequate early preparation prevents students in high school and college from taking science and mathematics courses (MSEB, 1990).

Language

When English is spoken in the home, or when an Indian-English dialect is spoken, classroom English is not reinforced outside the school. Even Indian students who speak English may not understand the nuances of English-language thinking (Davison, 1992). Academic performance relates



heavily to language proficiency. Students must possess "deep structure" rather than "surface structure" language development in their first language to best learn a second language.

Because of the differences in categorization and abstraction in American Indian languages, learning science becomes a problem of learning an entirely new specialized language (Schindler & Davison, 1985). Students have difficulty extracting information from science texts due to the highly complex nature of the vocabulary, the organization of the text, the language structure, their literacy skills, and the study required for mastery

Parental involvement in classrooms, on advisory boards and school boards, and on program role models, mentors, and consultants is essential.

of the concepts. Students often cannot comprehend the material because of the terminology used and there may be many words unfamiliar to them. Often students recognize all the words and think they know meanings; however, a word may have a dozen meanings and the students may know only one (Gilliland, 1992).

Often students are not given enough appropriate instruction in mathematics vocabulary. For example, confusion occurs when such terms as "*factor*" and "*product*" have specialized meanings in the mathematics classroom different from their regular English language meaning. Students whose predominant language is not English have difficulty solving story problems in mathematics (Davison, 1992).

In addition, many of the programs that target language-minority students suffer from the compensatory education stigma. Because students in compensatory education programs have low test scores in the "basics," including reading skills and language improvement, almost all attention is focused on improving achievement in these areas. Other subjects, such as science, tend to be addressed incidentally and haphazardly after the other work of the schoolday is done (DeAvila, 1985).

Cultural and Personal Sensitivities

Particularly in the study of biology, cultural beliefs may make certain activities offensive to students. The killing of any animal or plant simply to be studied may be considered a sacrilege. Dissection is often explicitly forbidden due to the prohibition against touching the dead. Certain animals are considered to have special powers and to discuss them may be considered to bring harmful consequences (Gilliland, 1992; Levy, 1992).

As shown in the discussion above, a clear need exists for educators to identify guidelines for the development and use of culturally relevant strategies and materials for American Indian/Alaska Native precollege students in mathematics, science, and technology. Hodgkinson et al. (1990) wrote that American Indians "should be more in control of their future by having more control over their children's education" (p. 21). Effective education for American Indians must have a holistic approach that includes all those involved in the educational process—students, educators, and the communities themselves.

This conference continued the process of identifying cultural concerns and issues within teacher enhancement, student, and curriculum development programs. It also provided educators the opportunity to develop a recommended set of guidelines that reflect cultural and community needs associated with mathematics, science, and technology education for precollege American Indian students.

APPENDIX C:
SUGGESTED ADDITIONAL RESOURCES

Books/Documents

American Association for the Advancement of Science. (1990). Sourcebook for science, mathematics & technology education. Washington, DC:

American Council on Education. (1989). Minorities on campus: A handbook for enhancing diversity. Washington, DC:

Burns, M. (1992). About teaching mathematics. White Plains, NY: Math Solutions Publication.

Cahape, P., & Howley, C. (1992). Indian Nations at risk: Listening to the people (Summaries of Papers Commissioned by the Indian Nations At Risk Task Force of the US. Department of Education). Charleston, WV:

Cajete, G. (1994). Look to the mountain. Durango, CO: Kivaki Press.

Davidson, N. (1990). Cooperative learning in mathematics, Menlo Park, CA: Addison-Wesley.

Drake, S. (1993). Planning integrated curriculum. Alexandria, VA: Association for Supervision and Curriculum Development.

ERIC Clearinghouse for Rural Education and Small Schools. (1993). Rural education directory: Organizations and resources. Charleston, WV: Appalachia Educational Laboratory.

Freedman, R. (1994). Open-ended questioning: A handbook for educators. Menlo Park, CA: Addison-Wesley Publishing.

Gibbs, J. (1994). Tribes: A new way of learning together. Santa Rosa, CA: Center Source Publications.

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Johnson D, & Johnson R,. (1994). The New Circles of Learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Kagan, S. (1991). Cooperative learning. San Juan Capistrano, CA:, Resources for Teachers, Inc.

Kagan, M & Kagan, S. (1992). Advanced cooperative learning : Playing with the elements, San Juan Capistrano, CA: Kagan Cooperative Learning

Math and Science Teachers for Reservation Schools. (1993). Earth's caretakers, Native American lessons. Lawrence, KS: University of Kansas.

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Native Education Initiative of the Regional Educational Laboratories. (1993). Native education directory: Organizations and resources for educators of native peoples of the United States and territories. Charleston, WV:

Northwest Indian Child Welfare Institute. (1987). Cross-cultural skills in Indian child welfare. Portland, OR: Parry Center for Children.

Oden, S., Kelly, M., Ma, Z., Weikart, D. (1992). Challenging the potential. Ypsilanti, MI: High/Scope Educational Research Foundation.

Reyhner, J. (1992). Teaching American Indian students. Norman, OK: University of OK Press.

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Stake, R., Raths, J., St. John, M., Trumbull, D., Jenness, D., Foster, M., Sullivan, S., Denny, T., Easley, J. (1993). Teacher preparation archives: Case studies of NSF-funded middle school science and mathematics Teacher preparation projects. Urbana, IL: University of Illinois, CIRCE.

Taylor, C. (1993). Guide to multicultural resources. Atkinson, WI: Praxis Publications.

U.S. Department of Energy. (1993). Guidebook to excellence: A directory of federal facilities and other resources for mathematics and science education improvement. Oak Ridge, TN: Directorate for education and human resources, NSF.

Wilke, R. (1993). Environmental education: Teacher resource handbook. Millwood, New York: Kraus International.

Journals

American Indian and Alaska Native Mental Health Research

Arithmetic Teacher

Canadian Journal of Native Education

Cooperative Learning

Journal of American Indian Education

Journal of Navajo Education

Science

Standards

Curriculum and Evaluation Standards for School Mathematics Addenda Series, National Council of Teachers of Mathematics (1992)

Curriculum and Evaluation Standards for School Mathematics, National Council of Teachers of Mathematics (1989)

National Science Education Standards, National Academy Press (1994)

Evaluation

Stevens, F., F. Lawrenz & Sharp, L. (1994). User-Friendly Handbook for Project Evaluation: Science, Mathematics, Engineering and Technology Education. National Science Foundation, Arlington, VA.

Worthen, B., & J. Sanders. (1987). Educational evaluation. White Plains, NY: Longman.

USER FEEDBACK FORM

Instructions: Please complete this form after you have reviewed and/or used this Guidelines document.

Your primary interest in this document is as a (check one)

1. K-4 Teacher	☐	5. Program Grant Reviewer	☐
2. 5-8 Teacher	☐	6. Program Evaluator	☐
3. 9-12 Teacher	☐	7. Funding Agency	☐
4. Curriculum Developer	☐	8. Other	

Briefly describe how you have or will make use of this Guidelines document as related to your primary interest area? (Include type of program or project you are involved in, if applicable.)

Rate the following items 1-5. *Use #6 for not applicable.*	**Not Helpful**				**Very Helpful**	**NA**
How effective was this document in increasing your understanding and application of the cultural needs of American Indian/Alaska Native students in teaching and learning?	1	2	3	4	5	6
How helpful was this document in planning your science, mathematics, and technology educational instruction/program for American Indian/Alaska Native students?	1	2	3	4	5	6
How helpful was this document in implementing your science, mathematics, and technology educational instruction/program for American Indian/Alaska Native students?	1	2	3	4	5	6
How helpful was this document in evaluating your science, mathematics, and technology educational instruction/program for American Indian/Alaska Native students?	1	2	3	4	5	6
How effective was this document in generating positive change in your instruction/program climate and interactions with American Indian/Alaska Native students?	1	2	3	4	5	6

Additional Comments:

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NOTES